FACTSHEET

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PROJECT TITLE

Preliminary results on the impact of allelopathic cover crops and its termination method in cash crops grown subsequent season

RESEARCHERS

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Background

More than 60% of weed management is through recurring herbicide applications, leading increased instances of weed resistance. Allelopathy is the influence, usually detrimental, of one plant on another, where toxic substances are released when a plant dies, or produced through decaying tissue(Zimdahl R.L., 2018). These secondary metabolites may establish direct or indirect harmful or beneficial effects (Reigosa et al., 2006). Allelopathy can affect the growth and yield of another crop (Batish et al., 2001), b) develop autotoxicity, meaning chemicals expelled from plant residues of a species can hinder the growth of seedlings of the same species (Yu and Matsui, 1997). Thus, if managed properly, allelopathy can be a great alternative in weed management.

This study is preliminary and novel, because a) weed species and number of individuals per species will be evaluated within the allelopathic cover crop as well as the subsequent cash crops such as wheat, canola and peas and b) it aims to evaluate if allelopathy is affected if cover crops as well as cover crop mixtures are roller-crimped or incorporated in the soil before the cash crop is seeded. This research is unique because allellopathy is still an untouched subject for many growers. Extending knowledge through this project might increase grower interest in using allelopathic crops as another way to induce more weed suppression.

In the following growing season, cash crops such as canola, wheat and peas will be seeded as monocrop at each site respectively. Much like the first study year, soil samples will be collected for chemical analysis, a burndown herbicide application will be broadcasted before seeding and fertilization will be adjusted to target yields such as 40, and 50, for canola and wheat respectively (Government of Alberta 2024), as peas will not be fertilized. Harvest per plot will be weighed and recorded.

OBJECTIVES

This study aims to explore in further detail the allelopathic effects of rye, ryegrass, hairy vetch and sunflower and mixtures between these cover crops (rye + ryegrass, rye + hairy vetch, rye + sunflower, ryegrass + hairy vetch, ryegrass + sunflower and hairy vetch + sunflower). This study is preliminary, because a) weed species and number of individuals per species will be evaluated within the allelopathic cover crop as well as the subsequent cash crops such as wheat, canola and peas and b) it aims to evaluate if allelopathy is affected if cover crops as well as cover crop mixtures are roller-crimped or incorporated in the soil before the cash crop is seeded.

EXPERIMENTAL SET UP

The experiment was located at two sites in Lakeland Agricultural Research Association. These sites are St Paul (54°5′N, 110°15′W), and Fort Kent (54°18′N, 110°37′W). Aside from the herbicide burndown treatments there were no further applications of herbicide for the rest of the growing season. Rye (Secale cereal L), annual ryegrass (Lolium multiflorum L.), hairy vetch (Vicia villosa L.), sunflower (Helianthus annus L.) were sown at 4.9, 4.5, 20.2 and 1.3 g m^2 and mixtures of these crops (rye + ryegrass, rye + hairy vetch, rye + sunflower) were also sown. Except for sunflower, seeding rate of all other cover crop species was doubled. The experiment was set up as a four replicate, complete random design. Hand weeding, either by a stirrup hoe and/or a wheel stirrup hoe between seed rows around the first week of June. The split plot factor is the cover crop termination style: roller crimped or incorporated. An untreated control, where no cash crop is seeded will also be included.

For both study years, a quadrat of 25X25 cm will be situated randomly across the plot. Every second week of the months of June, July, and August, weed species and number of weeds per species were counted in one of these quadrats (species richness). Quadrat selection was random. Afterwards, biomass was taken out of this one quadrat and separated as weeds and cover crop species. For the second study year, biomass will be taken before the cash crop harvest and separated as weeds, cash crops and if present, cover crop harvest.

RESULTS

In the first study year, preliminary results indicated that less weed biomass was found in plots seeded to rye either as a monocrop or as an intercrop (Table 1). On second place annual ryegrass as an intercrop and mixes of annual ryegrass with sunflower and hairy vetch are optimal weed mitigators (Table 1). A smaller estimate was also found when comparing weed biomass in unseeded plots with all plots seeded with plots seeded to sunflower both as a monocrop and as part of an intercrop (Table 3).

Estimates can be ranked as follows: Sunflower and sunflower intercrops<annual ryegrass and annual ryegrass intercrops <rye and rye intercrops<hairy vetch and hairy vetch intercrops. Weed biomass ratio was calculated by dividing mean values of weed biomass in a seeded plot over weed biomass weighed in unseeded plots. Results in tables 4, 5 and 6 reflect the same statistical outcomes found in tables 1, 2 and 3. However weed biomass ratio estimate comparisons showed that rye, annual ryegrass and hairy vetch treatments weed estimate ratios were greater than those found in seeded to the cover crops afore mentioned as monocrops. In addition, weed biomass ratio estimate comparison value between hairy vetch monocrop plots and any plots where hairy vetch was grown was significant.

In general, P-values obtained for RNE, Ktotal and AYL were not significantly different. This means that dominance of cover crops against weeds was the same (RNE) (Table 8). Neither allelopathic cover crop was more dominant with respect to the other either as a monoculture or as part of an intercrop system (K) (Table 8). Moreover, there was no yield gain from any allelopathic cover crop over the other and thus there was no difference against actual yield loss (Table 8).

Table 1. Weed biomass in g per meter squared found at each cover crop and bicultural cover crop treatments in Fort Kent and Saint Paul, Alberta

Principal cover crop	Companion cover crop	Weed biomass g m^{-2}	Standard error	
Rye	Annual Ryegrass	36.20	4.5	G
	Sunflower	67.82	4.5	FG
	Hairy vetch	122.85	4.5	EF
Annual Ryegrass	Sunflower	145.49	4.5	EF
	Hairy vetch	223.91	4.5	DE
Hairy vetch	Sunflower	446.40	4.5	BC
Rye	No crop	64.92	4.5	FG
Annual Ryegrass	No crop	191.42	4.5	DE
Hairy vetch	No crop	304.30	4.5	CD
Sunflower	No crop	633.66	4.5	B
No crop	No crop	1056.12	4.5	A

Table 2. Weed biomass estimate comparisons between plots left unseeded with plots seeded with either monoculture of annual ryegrass, hairy vetch, rye and sunflower with intercrops between these cover crops and unseeded plots in Fort Kent and Saint Paul, Alberta

Comparison between	with	Weed biomass g m^{-2}	Standard error	P-value
Unseeded plots	All seeded plots	349.52	3.1	**0.0001**
Sunflower	Sunflower intercrops	129.07	3.8	**0.0001**
Hairy vetch	Hairy vetch intercrops	36.14	3.8	**0.0026**
Rye	Rye intercrops	21.90	3.8	**0.0183**
Annual ryegrass	Annual ryegrass intercrops	7.91	3.8	0.1532

Table 3. Weed biomass estimate comparisons between plots left unseeded with plots seeded with unseeded plots with monocultures and intercrops of either annual ryegrass, hairy vetch, rye and sunflower in Fort Kent and Saint Paul, Alberta

Comparison between	with	Weed biomass g m^{-2}	Standard error	P-value
Unseeded plots	All seeded plots	349.52	3.1	**0.0001**
	Hairy vetch seeded plots both monocrop and in intercrops	437.78	3.6	**0.0001**
	Rye seeded plots both monocrop and in intercrops	431.63	3.6	**0.0001**
	Annual ryegrass seeded plots both monocrop and in intercrops	382.74	3.6	**0.0001**
	Sunflower seeded plots both monocrop and in intercrops	251.10	3.6	**0.0001**

Table 4. Weed biomass ratio found at each cover crop and bicultural allellopathic cover crop treatments in Fort Kent and Saint Paul, Alberta

Principal cover crop	Companion cover crop	Weed biomass ratio	Standard error	
Rye	Annual Ryegrass	0.06	4 X10-3	E
	Hairy vetch	0.13	4 X10-3	DE
	Sunflower	0.14	4 X10-3	DE
Annual Ryegrass	Sunflower	0.22	4 X10-3	CD
	Hairy vetch	0.24	4 X10-3	CD
Hairy vetch	Sunflower	0.43	4 X10-3	BC
Rye	No crop	0.08	4 X10-3	DE
Annual Ryegrass	No crop	0.23	4 X10-3	CD
Hairy vetch	No crop	0.36	4 X10-3	C
Sunflower	No crop	0.62	4 X10-3	B
No crop	No crop	0.96	4 X10-3	A

Table 5. Weed biomass ratio estimate comparisons between plots left unseeded with plots seeded with either monoculture of annual ryegrass, hairy vetch, rye and sunflower with intercrops between these cover crops and unseeded plots in Fort Kent and Saint Paul, Alberta

Comparison between	with	Weed biomass ratio	Standard error	P-value
Unseeded plots	All seeded plots	0.18	5 $X10^{-3}$	**0.0001**
Sunflower	Sunflower intercrops	0.02	4 $X10^{-3}$	**0.0003**
Hairy vetch	Hairy vetch intercrops	-0.02	4 $X10^{-3}$	**0.0132**
Rye	Rye intercrops	-0.03	4 $X10^{-3}$	0.0915
Annual ryegrass	Annual ryegrass intercrops	-0.05	4 $X10^{-3}$	0.3749

Table 6. Weed biomass ratio estimate comparisons between plots left unseeded with plots seeded with unseeded plots with monocultures and intercrops of either annual ryegrass, hairy vetch, rye and sunflower in Fort Kent and Saint Paul, Alberta

Comparison between	with	Weed biomass ratio	Standard error	P-value
Unseeded plots	All seeded plots	0.18	5 $X10^{-3}$	**0.0001**
	Rye seeded plots both monocrop and in intercrops	0.26	5 $X10^{-3}$	**0.0001**
	Sunflower seeded plots both monocrop and in intercrops	0.23	5 $X10^{-3}$	**0.0001**
	Annual ryegrass seeded plots both monocrop and in intercrops	0.20	5 $X10^{-3}$	**0.0001**
	Hairy vetch seeded plots both monocrop and in intercrops	0.10	5 $X10^{-3}$	**0.0001**

Table 7. Parameters that will be used to assess the success of the intercrop and interseeding systems

Competition indices	Relative neighbour coefficient RNE	Relative crowding coefficient K	Actual Yield Loss AYL
Formulae	$\frac{(B_{control} - B_{mixture})}{z}$	$K_1K_2 = \frac{Y_{ic1}SR_{ic2}}{(Y_{mc1} - Y_{ic1})SR_{ic1}} \frac{Y_{ic2}SR_{ic1}}{(Y_{mc2} - Y_{ic2})SR_{ic2}}$	$AYL_l + AYL_c = \left(\frac{\frac{Y_{ic1}}{SR_{ic1}}}{\frac{Y_{mc1}}{SR_{mc1}}} - 1\right) + \left(\frac{\frac{Y_{ic2}}{SR_{ic2}}}{\frac{Y_{mc2}}{SR_{mc2}}} - 1\right)$
Definition	Measures competition between weeds and cover crops. The greater the RNE value the more the competition of the crop or crop mixture against weeds	Relative dominance of once allelopathic cover crop species over the other. Greater, positive values denote more dominance	Proportionate yield loss or gain of each species of intercropping. Greater, positive values denote more yield gain over the other species in the intercropping system
Reference	Weigelt and Jolliffe, 2003	Ghosh P.K., 2004	Banik et al., 2000

[a]Yield and seeding rate parameters are labelled as Y and SR, respectively. ic= intercrop mc= monocrop. Numbers 1 and 2 determine crops in the system.

Table 8. P-values obtained based on main effect and interactions of these effects on intercropped cover crops sown at Fort Kent and Saint Paul

	Coefficients		
Effect	RNE	K (total)	AYL (total)
Main crop	0.70	0.24	0.15
Companion crop	0.21	0.82	0.17
Main crop*companion crop	0.47	0.14	0.05

TAKEAWAYS

Weed biomass estimate comparisons outcomes demonstrated that all plots seeded with allelopathic plots in comparison to unseeded plots (Table 2). The smallest significant difference in weed biomass estimates was found in plots seeded to rye as monoculture compared to rye seeded in companion with either annual ryegrass, hairy vetch and sunflower (Table 2).

More weeds were mitigated with plots containing hairy vetch, followed by rye, annual ryegrass and finally sunflower.

Hairy vetch seeded plots had a weed biomass ratio greater than weed biomass ratio found in hairy vetch monocrop plots. Lack of difference in weed biomass ratio estimate comparisons in rye and annual ryegrass can be explained as a uniform allelopathic effect from this cover crops.

In conclusion, rye and annual ryegrass, either grown single or as part of an intercrop have a significant effect in weed reduction as shown in weed biomass and weed biomass ratios. Sunflower on the other hand requires to be intercrop so weed mitigation can increase because as a monocrop it is a very weak allelopathic crop in comparison to rye and annual ryegrass.

Competition indices between the allelopathic crops tested under intercrop systems indicated that the first year is too early to indicate any competitive advantage from one allelopathic cover crop species to the other and more data is required to have more robust and likely, significant outcomes.

BIBLIOGRAPHY

Banik, P., T. Sasmal, P.K. Ghosal, and D.K. Bagchi. 2000. Evaluation of Mustard (Brassica compestris Var. Toria) and Legume Intercropping under 1 : 1 and 2 : 1 Row-Replacement Series Systems. J Agron Crop Sci 185(1): 9–14. doi: 10.1046/J.1439-037X.2000.00388.X.

Batish, D.R., Singh H.P., and Kohli R.K. 2001. Vegetation exclusion under Casuarina equisetifolia L.: Does allelopathy play a role? Community Ecology 2(1): 93–100.

Ghosh P.K. 2004. Growth, yield, competition, and economics of groundnut/cereal fodder intercropping systems in the semi-arid tropics of India. . Field Crop Research 88: 227–237.

Reigosa, M.J., N. Pedrol, and L. González. 2006. Allelopathy A physiological process with ecological implications (Reigosa M.J., Pedrol N., and Gonzalez L., editors). First. Springer, Dordrecht, The Netherlands.

Weigelt, A., and P. Jolliffe. 2003. Indices of plant competition. Journal of Ecology 91: 707–720. doi: 10.1046/j.1365-2745.2003.00805.x.

Yu, J.Q., and Y. Matsui. 1997. Effects of root exudates of cucumber (Cucumis sativus) and allelochemicals on ion uptake by cucumber seedlings. J Chem Ecol 23(3): 817–827. doi: 10.1023/B:JOEC.0000006413.98507.55.

Zimdahl R.L. 2018. Integrated weed management for sustainable agriculture (Zimdahl R.L., editor). First. Burleigh Dodds Science Publishing, Philadelphia, Pensylvannia, USA.